

A BURIED EARTH ANALOGUE TO MARTIAN CHAOTIC TERRAINS. A.P. Rossi¹, V.A.I. Huvenne^{2,3}, J.P. Henriot³, R. Wagner⁴, E. Hauber⁴, A. Chicarro¹, S. Di Lorenzo⁵, G. Neukum⁶ and the HRSC Co-Investigator Team. ¹RSSD of ESA, ESTEC, NL 2200 AG, Noordwijk, The Netherlands, arossi@rssd.esa.int. ²Challenger Division for Seafloor Processes, National Oceanography Centre, Southampton, United Kingdom. ³Renard Centre of Marine Geology, Department of Geology and Soil Science, Ghent University, Belgium ⁴Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany, ⁵IRSPS, Università d'Annunzio, 65127 Pescara, Italy, ⁶Institut für Geologische Wissenschaften, Freie Universität Berlin, Germany.

Introduction: Martian chaotic terrains have a peculiar morphology and are rather common landforms on Mars, even if they are not evenly distributed, being concentrated in the outflow channels source region, close to the eastern end of the Valles Marineris system. Unlike several other features (e.g. fluvio-lacustrine, volcanic, tectonic), they have few counterparts on Earth. An example may be certain types of submarine slides [1]. We compare Martian chaotic terrains with a recently discovered buried submarine slope failure offshore Ireland, in the Porcupine Basin [2] (Fig. 1). Chaos areas on Mars have several similarities with this terrestrial analogue, but also some differences, the first being the scale, which is one order of magnitude smaller for the Porcupine slope failure (Fig. 2, 3).



Fig. 1: Location map of the Porcupine Basin slope failure.

Porcupine slope failure and chaos on Mars: The Porcupine Basin slope failure is located offshore Ireland, is embedded in Tertiary sediments and covered by younger deposits. It is characterized by a partially disrupted slab, with preserved portions occurring as polygonal blocks, as visible from high-resolution 3D seismic data (Fig. 2). The slope failure is buried and the disrupted volume between preserved mesas is filled with a chaotically emplaced “matrix” [2].

Mesas in Martian chaos areas are usually up to a few tens of km wide, whereas knobs are usually from a

few hundred meters to a few km. Instead, blocks in the Porcupine slope failure are up to a few hundred meters wide (Fig. 3). The blocks (or mesas) in Porcupine slope failure occupy an average of about 42% of the area. The percentage of undisrupted mesas however varies across the slope failure. Measurements in few Martian chaos areas show comparable but slightly variable percentage of preserved mesas (e.g. around 20-30% for Hydraspis and Aureum Chaos). Locally in chaotic terrain-like areas such as the area north of Deuteronilus Mensae, the percentage of preserved blocks can be as low as 15%, possibly due to further degradation and erosion of the mesas, or different and more complex forming processes.

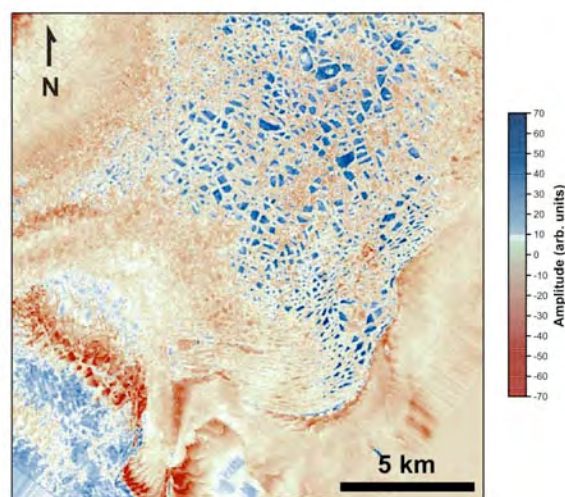


Fig. 2: Amplitude map at the top of the Porcupine Basin failure, from 3D seismics. (modified from Huvenne et al., 2002)

Discussion: Apart from the strong morphological resemblance, the main similarity among the Porcupine failure and Martian chaotic terrains could be the fluidization of a relatively incompetent (possibly volatile-rich) lower layer, overlain by more competent strata. The Porcupine Basin slope failure appears to have frozen right after its formation [2], being later buried by younger sediments. Moreover, the matrix of disrupted sediments between blocks is in place, while in Martian chaotic terrains it has been removed by outflow channels or other processes (e.g., in closed chaos). As sug-

gested by [2], a possible further step of the Porcupine Basin slope failure could have been complete fluidization. Martian chaotic terrains show variable levels of disruption, e.g., when just a few knobs are present in chasmatas, such as Eos Chasma. This would suggest the removal of most of the pre-existing material.

Martian chaotic terrains have probably experienced more complex histories as compared to the “frozen” Porcupine slope failure, i.e. with the removal of “matrix” material [2] between knobs and mesas, and possibly with subsequent sapping and/or mass wasting processes acting on the mesa cliffs.

Strictly speaking chaotic terrains are concentrated in the outflow channel source areas, east of the Tharsis bulge. Several chaos-like features, usually named as mensae, are located in areas of high topographic gradient (Fig. 4), where there is most chance for slope instability.

Chaotic or chaotic-like terrains on Mars develop in a variety of settings and with a different level of maturity. They appear at places as incipient cracks in craters, which could be a precursor of chaos formation. They can also occur as degraded chaos-like morphologies, likely affected by sapping at some point (e.g. Deuteronilus or other mensae) Pre chaos-like polygon features in craters are characterized by the highest mesa/total area ratio among the various kinds of disrupted terrains.

There is evidence for a long lasting activity in Martian chaotic terrains [e.g. 3], with possible multiple processes acting during and after chaos formation [e.g. 4].

A role of gas hydrates on chaotic terrain formation on Mars has also been mentioned [5]. There is no clear evidence whether this applies to the Porcupine Basin slope failure [6].

Fluidization possibly occurred on both Martian chaotic terrains and in this terrestrial submarine failure. It is not clear yet whether basal sliding, present in the Porcupine Basin, has occurred in certain Martian chaotic terrains, with horizontal movements likely to have been small compared to preserved mesa sizes.

It is also possible also that chaotic terrain formation, geometry and location is affected to some extent by existing buried structures [e.g., 3]. The role of pre-existing structures at the mesa/knob scale on Mars is not well constrained, but the analogy with certain sediment deformation features (not fully understood yet), such as polygonal faulting [i.e. in 7] could serve in interpreting the polygonal nature of several chaos-like areas.

Conclusions: The Porcupine Basin slope failure has striking morphological similarity with Martian chaotic terrains. Basal sliding, present in the Porcupine Basin slope failure, is difficult to detect and quantify

on Mars, due to the lack of subsurface data (but Marsis and Sharad might help). The discovery and study of similar structures on Earth [8] could provide clues to the complex genesis of chaotic terrains on Mars. Therefore, a search for further (buried) similar features in the (sub)surface of continental margins and slopes could be of great help.

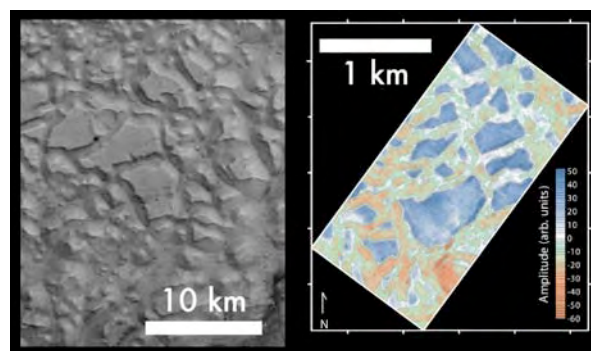


Fig. 3: HRSC orbit 401 nadir band over Iani Chaos (left) compared to one order of magnitude smaller blocky pattern of the Porcupine Basin slope failure (right, modified from [2])

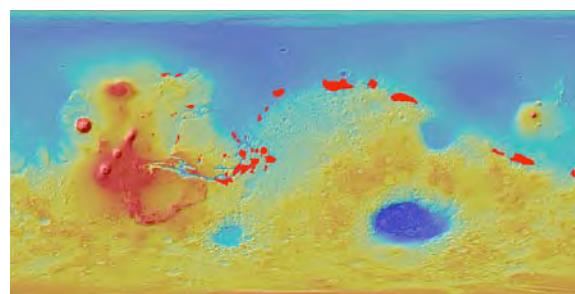


Fig 4: Chaotic terrain and chaos-like features on Mars (in red): Several disrupted terrains occur in areas with high topographic gradient, such as the dichotomy boundary.

Acknowledgements: 3D seismic data were kindly provided by Statoil Exploration (Ireland) Ltd. and partners.

References: [1] Nummedal A. B. and Prior C. D. (1981) *Icarus*, 90, 1151–1154. [2] Huvenne V. A. I. et al. (2002) *Terra Nova*, 32, A74. [3] Rodriguez, J. A. P. et al (2004) *Icarus*, 175, 36–57. [4] Ori, G. G., Mosangini, C. (1998) *JGR*, 103, E10, 22713–22724. [5] Komatsu, G. et al. (2000) *LPS XXXI*, Abstract #1434. [6] Henriot, J.P. et al. (2001) in Shannon, P. M. et al. (eds.), *Geol. Soc. Lon. Spec. Pub.* 188, 375–383. [7] Van Rensbergen et al. (eds.) *Geol. Soc. Lon. Spec. Pub.* 216, 528 p. [8] Gee, M. J. R. et al. (2005) *Marine Geology*, 214, 287–294.